Space Weather Technical Forecast

Issued on Sunday 5 January 2025 at 00:24 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares expected, with an increased chance of X-class flares. Chance of further G1 Minor Geomagnetic Storms Day 1 (05 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity increased to High levels with an X1.8 flare observed at 04/1248UTC, from AR3947 in the northeast disk. This region also looks responsible for a M7.6 flare at 04/0518 UTC.

There are fifteen sunspot regions on the Earth-facing disc, with three unnumbered regions. Despite the large number of spots on the Earth facing-disc, many are small and generally magnetically simple. AR3947 in the northeast is the largest and most complex spot and has been responsible for the bulk of recent activity, with three lower X-class flares now recorded since appearing over the eastern limb. It features several moderately sized spots, including a delta region in its trailing spots and is now analysed as a Ekc Beta-Gamma-Delta. AR3943 in the east shows some magnetic complexity and has seen some growth in its intermediate spots in recent hours. Some slight decay of AR3939 and AR3945 has taken place, otherwise there has been little change to the remaining regions on the Earth facing-disc.

No Earth-directed CMEs were observed during the period, though 2 CMEs visible on Lasco C3 imagery off the west limb are to be analysed.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, started the period around 420km/s, but steadily increased through the day, likely due initially to a CME arrival around 04/0200UTC and then a connection with the High Speed Stream from CH05/+, to a strong 690km/s. Density was predominantly at average to below average levels. The Interplanetary Magnetic Field, Bt, started moderate, peaking at a strong 17.8nT around 04/1143 UTC, before easing back to weak levels later. The north-south component, Bz, fluctuated between negative and positive through much of the period, ranging between +13nT and -15nT. The Phi angle started negative (towards the Sun), then become mostly positive (Away the Sun) from around 04/0200UTC.

Geomagnetic activity was at Quiet levels until 04/0300 UTC. Then became mostly Active (Kp4) for the remainder of the period, with G1/Minor geomagnetic storm conditions recorded between 04/0300-0900 UTC and 04/1800-2100 UTC.

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Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 breached the S1 Minor Storm threshold at 04/2305UTC, probably in response to the X-flare. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24 hr fluence well below Active. The 05/0000 UTC fluence observation was 3.02e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is forecast to be Moderate to High, with further M-class flares expected and a chance of further isolated X-flares. This risk increased given recent activity from AR3947.

Solar Wind / Geomagnetic Activity: Following the CME arrival combined with the coronal hole high speed stream solar wind speeds are expected to be strong or elevated for much of Day 1 (05 Jan) with speeds of 650km/s at first. From Day 2 (06 Jan) solar wind speeds should begin to slowly ease back to background levels below 400km/s.

Geomagnetic conditions are expected to be mainly Unsettled to Active (Kp3-4) through Day 1, with a chance of further G1 Minor geomagnetic storm intervals. Activity is forecast to subside to generally Quiet to Unsettled (Kp1-3) levels into Days 2 and 3.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux has exceeded the S1/Minor Storm threshold at first but should slowly ease back to nominal levels through the period. GOES16 high energy electron flux is expected to continue at background after recent CME and coronal hole activity. The associated fluence is expected to remain below the Active threshold throughout.

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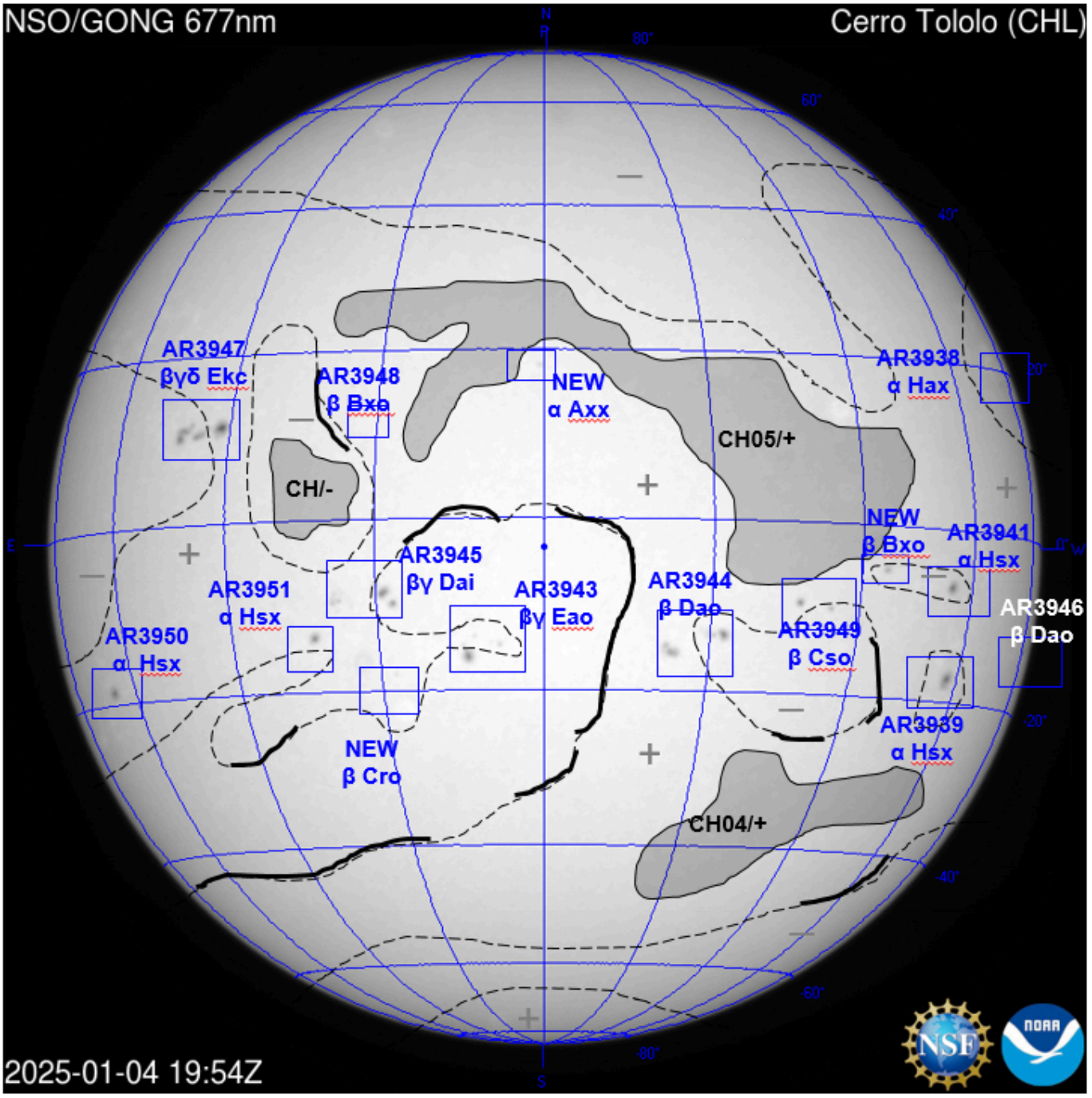
Figure 1: Solar Synoptic Map 04/2000 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A CME associated with the weak filament eruption on 01 Jan from the vicinity of AR3939 arrived at L1 around 04/0225 UTC.

There are two notable coronal holes on the Earth-facing disc, CH04+ in the south, and CH05+ in the north. The High Speed Stream from CH05+ arrived around 04/1400UTC. This is a persistent feature, although on its previous rotation covered a smaller area and was further to the solar east. Solar wind speeds associated with the feature reached 650km/s, giving Active to Minor Geomagnetic storm geomagnetic intervals. Elevated to Strong solar winds of 550-650km/s are likely on Day 1 (05 Jan), declining only slowly into Days 2 and 3 (06-07 Jan). This is broadly supported in MOSWOC ENLIL output.

Geomagnetic conditions are expected to be mainly Unsettled to Active (Kp3-4) through Day 1, with a chance of further G1 Minor geomagnetic storm intervals. Activity is forecast to subside to generally Quiet to Unsettled (Kp1-3) levels into Days 2 and 3.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	Yes	40	15	10	1
Strong	**G3**	No	5	2	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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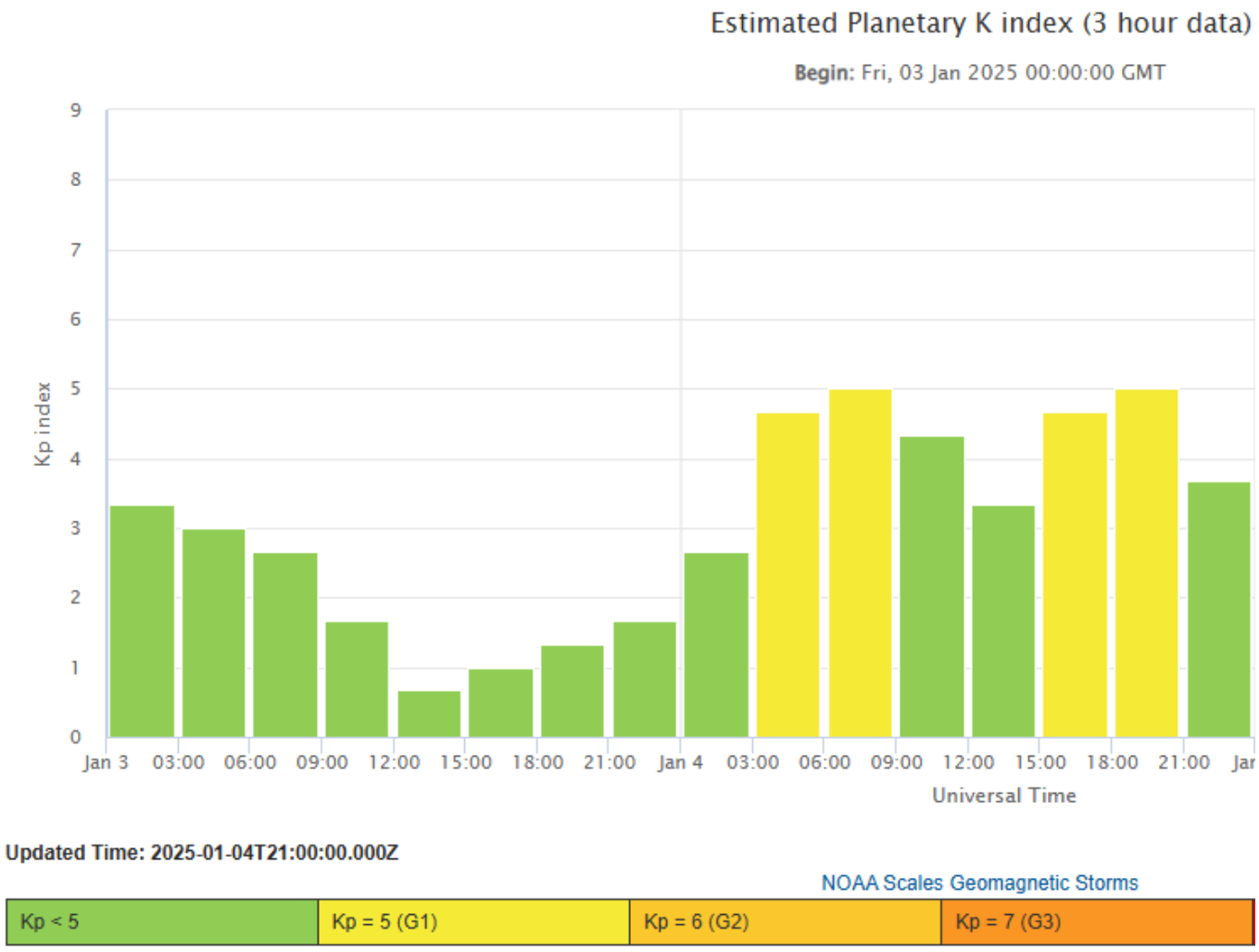
Figure 2: Estimated Planetary K index from NOAA/ SWPC



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Radio Blackouts - X-Ray Flares

Solar activity increased to High levels with an X1.8 flare observed at 04/1248UTC, from AR3947 in the northeast disk. This region also looks responsible for a M7.6 flare at 04/0518 UTC.

There are fifteen sunspot regions on the Earth-facing disc, with three unnumbered regions. Despite the large number of spots on the Earth facing-disc, many are small and generally magnetically simple. AR3947 in the northeast is the largest and most complex spot and has been responsible for the bulk of recent activity, with three lower X-class flares now recorded since appearing over the eastern limb. It features several moderately sized spots, including a delta region in its trailing spots and is now analysed as a Ekc Beta-Gamma-Delta. AR3943 in the east shows some magnetic complexity and has seen some growth in its intermediate spots in recent hours. Some slight decay of AR3939 and AR3945 has taken place, otherwise there has been little change to the remaining regions on the Earth facing-disc.

Some minor sunspot arrivals signalled by recurrence into the period with would balance the lose of some smaller regions, therefore a steady risk anticipated through the period at this stage, pending further developments.

Overall, activity is forecast to be Moderate to High, with further M-class flares expected and a chance of further isolated X-flares. This risk increased given recent activity from AR3947.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	70	70
Very Active	R3-R5 (X Class)	Yes	25	25	25	25

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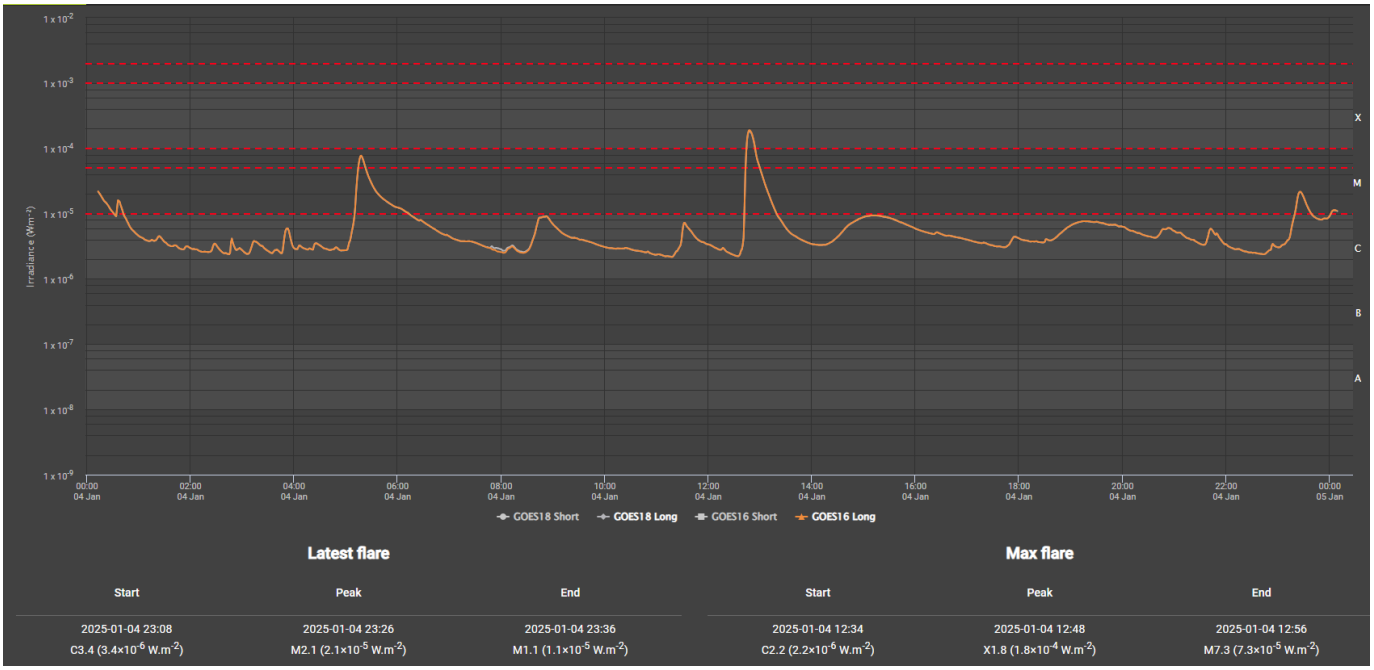
Figure 3: GOES16 X-Ray flux



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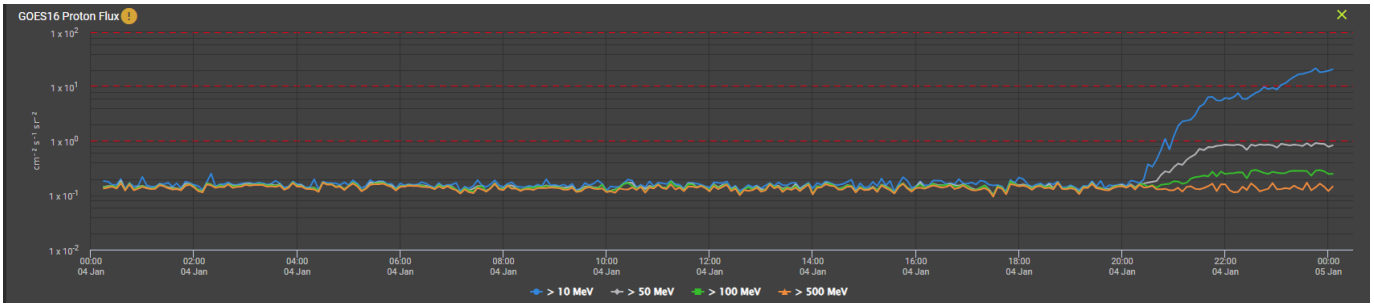
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux has exceeded the S1/Minor Storm threshold at first but should slowly ease back to nominal levels through the period. There is a chance of a further enhancement in the next few days should any further significant flares occur, including perhaps flares from regions which have now rotated off the west limb.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	80	30	20	10
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES16 Proton Flux



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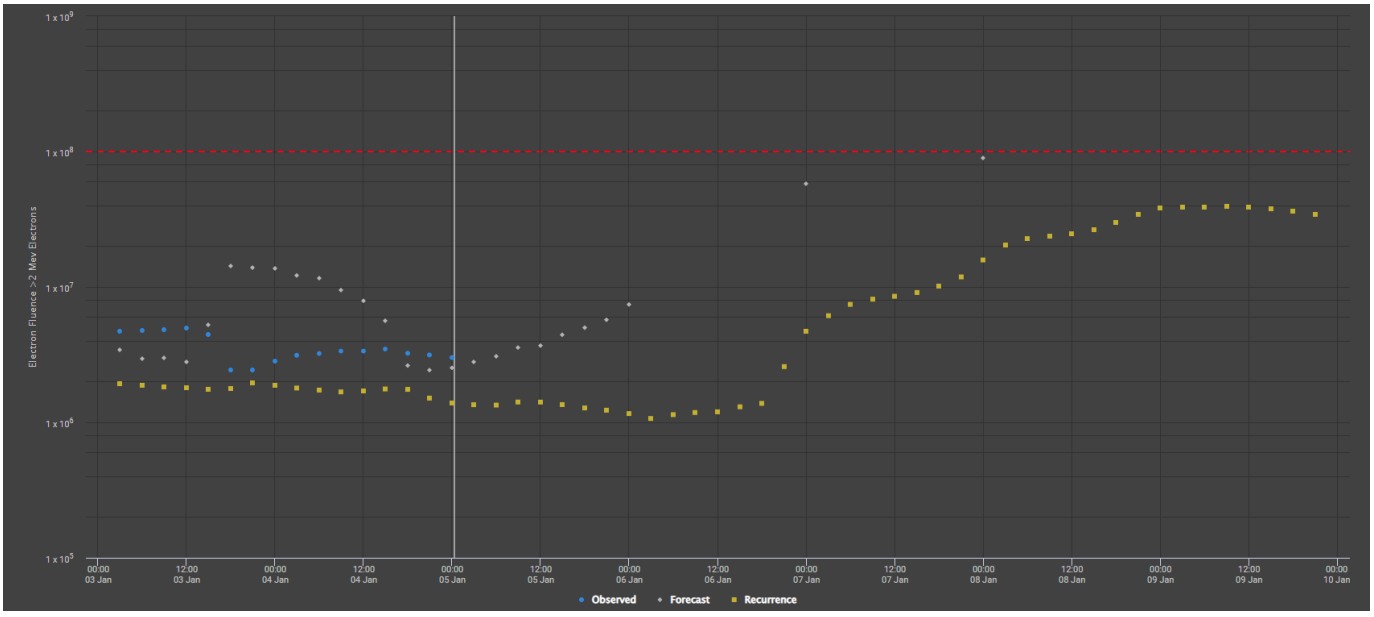
High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently at background levels, following the CME arrival on the morning of the 04 Jan and the connection to the high speed stream from CH05+ which has resulted in strong solar winds, this is expected to continue to suppress the radiation belt away from GEO causing the electron flux to remain at background levels for most the period, but may rise to moderate levels towards the end of the period in the absence of any further enhancement.

Overall the associated 24-hour fluence is expected to persist below Active levels throughout, despite a rising trend possible later in the period. MOSWOC REFM output looks to be providing reasonable guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	10
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REF Model output



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